THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

[THIRD SERIES.]

No. 20. AUGUST 1859.

VII.—*On the Laws of Evolution of the Organic World during the Formation of the Crust of the Earth.* By H. G. Bronn*.

Under the above title, Bronn has just published, in German, his prize-essay sent to the Academy of Sciences of Paris. This memoir was prepared in response to a question proposed in 1853 by that Academy, and referred to the concourse in 1854, in the following form:—

"Study the laws of the distribution of fossil organic bodies in the different sedimentary strata according to the order of superposition:

"Discuss the question of their successive or simultaneous appearance and disappearance:

"Investigate the nature of the relations existing between the present state of the organic kingdom and its former states."

The Academy has indeed decided that Bronn's important work shall be printed; but, in accordance with the usages and customs of that Institution, we shall still, no doubt, have to wait some years to see the completion of its printing. Fortunately, M. Bronn has indulged us with a German translation of his memoir, which has the advantages over the original, in the first place, of being published, and, in the second, of being augmented by a multitude of notes, which place this work at the level of the state of science in 1858.

In place of making an analysis of this remarkable work, we have thought it best to submit to our readers a complete trans-

* From "Untersuchungen über die Entwickelungsgesetze der organischen Welt während der Bildungszeit unserer Erdoberfläche." Stuttgard, 1858. Translated by W. S. Dallas, F.L.S., from the Bibliothèque Universelle de Genève, 20th March, 1859, Archives des Sciences physiques et naturelles, p. 217.

lation of the last chapter, in which M. Bronn himself gives a summary of the essential results at which he has arrived.

E. Claparède.

I. *Results of the investigations of* M. Bronn *with regard to the distribution of fossil organisms in the natural series of sedimentary strata.*

The investigations contained in this work are a confirmation of the laws resulting from the purely geological study of the evolution of the crust of the earth in relation to the successive appearance of organized beings. They also bring to light certain facts which do not immediately result from those laws, although they are not in contradiction to them—facts which particularly deserve attention.

First fundamental law.

1. Organisms have made their appearance, in the sequence of time and in different localities, in conditions of type and number which were in relation to the external conditions of existence.

2. The appearance of the two organized kingdoms was simultaneous. It dates almost immediately from the first Neptunian deposits—that is to say, from an epoch when the central heat must have still exercised a considerable influence upon the surface of the globe. It was undoubtedly, from the first, the business of the organisms of both kingdoms to maintain the atmosphere in such a state that the proportions of oxygen and carbonic acid might be as favourable as possible to their own development, at least if we suppose that the chemical composition of the atmosphere was already constant and independent of other circumstances (*vide* 8).

3. The population of the surface of the earth was, originally, very uniform in all latitudes. It is only towards the middle of the tertiary period that we see the floras and faunas become essentially differentiated according to zones.

4. Both as regards its constitution and number, the primitive population of the surface of the earth corresponded with a hot climate, of tropical nature, uniform throughout the year. This results from the very fact that the climatic differences of the different zones were not manifested until a later period, in consequence of a refrigeration starting from the polar regions.

5. All the successive modifications of the animal and vegetable population of the surface of the globe have been effected by the annihilation of the older species and the continual appearance of new species, without there having ever been any gradual passage from one species to another.

6. The primitive types, whether animal or vegetable, were

the most widely different of all from those of existing nature. Some of them differed from the latter so much as to form sub-classes or orders,—most of them at least generically. But in proportion as, in the history of the earth, we approach the present epoch, we observe a constantly increasing concordance of the genera, or even, in certain cases, an identity of species with our existing nature.

7. In all times there have existed faunas and floras topographically distinct, in consequence of differences of conditions in the stations, by reason of the distribution of the seas and the elevation of mountains. But in proportion as the evolution of the surface of the earth multiplied and varied the conditions of stations, in proportion as seas were divided, continents extended, chains of mountains elongated, and summits elevated, we also see a diversification of the organized types and of their mode of grouping and association. Topographical faunas and floras became more clearly defined; and in all cases the number of species living together constantly became more considerable.

8. Amongst stations of remarkable nature, we must above all indicate the immense marshes of *Stigmaria* in the carboniferous epoch. Thanks to their long and numerous horizontal roots, extended at the surface of the water, the *Stigmariæ* appear in course of time to have furnished a multitude of other plants with the soil necessary for their development. The latter on perishing became buried in the marsh, and there, protected from the access of air, became gradually converted into coal, only permitting a small number of fragments to decompose and become rotten at the surface. It is thus that the accumulation of carbonized substances could take place in a comparatively rapid manner (nearly as in our peat-bogs), and the formation of very large strata of coal consequently required a time perhaps less considerable than is usually supposed. The alternations, repeated hundreds of times, of strata of coal and sandstones or argillaceous shales, teach us that at that time a slow and gradual sinking of the soil was taking place, during which the strata of vegetable matter which had just been formed were covered with mud and sand; then the soil rose again. These continual sinkings indicate the existence at this period of plutonic* movements of the crust of the earth, in consequence of which, abundant emissions of carbonic acid might take place during a long period, as we see at present in certain countries.

* It is, however, to be remarked, that such movements of the soil do not necessarily involve plutonic action. The works of MM. Bischoff, Volger, and others appear to show, on the contrary, that sinkings of this nature must, in most cases, have a cause entirely Neptunian.—E. Claparède.

It was, then, the business of these marshy forests to seize upon this carbonic acid and to fix its carbon at the bottom of the waters. In fact, if all the carbon contained in the organic substances now deposited in the sedimentary strata in the form of coal, bitumen, &c., had never existed in the atmosphere in the form of carbonic acid, no animal or vegetable life would have been possible. These coaly marshes of *Stigmariæ*, with their peculiar vegetation, seem to have reappeared here and there, when sinkings of the soil, combined with emissions of carbonic acid, again gave rise to similar conditions*.

9. Although the carbonic acid continually emitted was thus incessantly and slowly eliminated by the Stigmaria-forests, it is not the less probable that the cause of the depression of the soil (elevation of temperature), the carbonic acid contained in the air in greater proportion than at the present day, and the great development of the marshes of *Stigmariæ* all over the surface of the globe, must have exercised a very great influence upon the character of the rest of the vegetation. But these are effects which it is no longer possible to analyse, nor to refer with certainty to their particular causes.

10. A multitude of plants and animals, especially more than three-fourths of the terrestrial insects, birds, and mammals, which, either with regard to their food or habitation, are necessarily connected with certain genera, or even certain species of plants, could, of course, only appear after the latter. The inferior plants and animals are often less intimately connected with other organisms than others which are higher in the series.

11. The principal modifications which the external conditions of existence of organisms had to undergo, consisted, undoubtedly, in the division of the universal ocean into several seas, Mediterranean basins and Caspian lakes,—in the emergence of islands which increased in size, or even united with each other to form continents,—in the elevation of mountain-chains, &c. In parallelism with this transformation of the crust of the earth, the organized world presented analogous modifications. The population of the sea, at first entirely pelagic, became combined with a littoral population, then with a terrestrial but exclusively coast population, and lastly with continental populations, varying with flat and mountainous countries. It is this series of phænomena

* This, as far as we know, is the first time that these different conditions, such as the chemical composition of the air, depressions of the soil, the marshes of *Stigmariæ*, and the formation of coal, have been thus combined with each other. This combination seems to us to be equally natural and necessary; still we admit that this opinion would require to be better supported, and that it may undergo some modifications. It is still too new to allow us to develope it sufficiently; perhaps we may do so hereafter.—(*Author's note.*)

that we designate under the name of *terripetal evolution.* Either by the successive sequence of organisms, or by the transformation of their characters, even in cases in which the causes of transformation are unknown to us, this evolution is manifested to us as a perfectly general law of development, which we call the *terripetal law.* As, in general, the inhabitants of coasts are characterized by a higher degree of organization than the inhabitants of the depths of the sea, and the inhabitants of the dry land by a higher degree of organization than those of the waters, this law is intimately connected with a progressive development. The first terrestrial plants* (if we do not take into account the coals of Portugal, the Silurian nature of which is doubtful) date from the Devonian formation; the first amphibious animals make their appearance in very small number at the same epoch†. The first veritable inhabitants of the dry land, respiring air (insects) and walking, make their appearance in the carboniferous formation. From this moment the number of terrestrial organisms constantly increases, and finally predominates over that of the marine organisms.

Second fundamental law.

12. Besides this first law, there evidently exists a positive and *independent* law of creation, which manifests itself to us in the simplicity and perfect order of all the simultaneous or successive modifications of the organized world. The external conditions of existence only permitted the investigation of the plan which presided in the creation at each moment and in all the series of time from a perfectly negative point of view. But this second law, thanks to its positive character, furnishes us with the means of following the conducting clue with far more facility and conclusiveness than was permitted by the former, which is so complex. Hence results, in the first place, the strict uniformity in all the creation which existed simultaneously at each moment upon the whole surface of the earth; hence the simultaneous appearance and disappearance of genera and species in all regions and under every zone; hence the constant equilibrium between the plants and animals, the terrestrial and aquatic animals, the Herbivora and Carnivora in each creation; and all this realized far more exactly than could have happened under the influence of the external conditions of existence alone, which may certainly destroy, but can produce nothing. The unfolding of the plan

* The earliest land-plants now known are those indicated by the Lycopodiaceous seed-vessels and fragments of woody tissue in the uppermost Silurian beds.—Ed. *Annals.*

† If the *Telerpeton* of Elgin be here referred to, we may remark that it is very doubtful if this fossil be of Devonian age.—Ed. *Annals.*

of creation in the series of geological ages has taken place with a perfect consequentiality and in a perfectly independent manner. Systematic and progressive development, and the law which governs it, are facts which can no longer be misconceived. Nevertheless we must not represent this progressive development as consisting in the primitive appearance of the Phytozoa alone, which would be followed by the Actinozoa, then by the Malacozoa, then by the Entomozoa, and finally by the Spondylozoa, each class and each order being followed by the appearance of a class or order occupying a higher place in the scale of organization. In reality, the subkingdoms, for which the external conditions of existence at the most ancient period were sufficient, made their appearance simultaneously, or nearly so. These subkingdoms were represented by the classes and orders lowest in organization—by pelagic, swimming forms, respiring air by means of branchiæ. When, subsequently, the superior subkingdoms were rapidly created one after the other, the classes and orders which had first appeared were represented by types gradually ascending. This is what we observe in many cases, and in all the subkingdoms without exception, when we pass them in review class by class and order by order, so as to prove the period of their appearance and that of their culmination (appearance of the higher plants, the bony fishes, the mammalia).

13. This plan of succession is nowhere more evident than in the vegetable kingdom, in which we see several subkingdoms appear at first and simultaneously, followed by the successive appearance of the superior groups most nearly allied to them in organization, and which only attained their culmination subsequently. The perfectly natural consequence of this, was the comparatively far later appearance of the most highly organized groups of plants—groups which surpass all the others in the number of their genera and species; and yet, at least as far as we can now judge, the external conditions of existence would have permitted their appearance from the very first. It is not possible for us, now-a-days, to ascertain any cause to which may have been due the retardation of the appearance of the angiospermous Dicotyledons until the cretaceous epoch*, except the law of progressive development (at least unless we choose to assume that the emission of carbonic acid in the ancient epochs may have opposed their production).

14. The late appearance of the angiospermous Dicotyledons is undoubtedly, of all causes, that which had the most importance in retarding the appearance of most of the terrestrial animals, such as the insects, birds, and mammalia. In all cases, the

* We must recollect that at least one angiosperm has been quoted from the Coal-measures. See Lyell's 'Manual,' 1855, p. 374.—Ed. *Annals*.

marine omnivorous and carnivorous types, and, amongst the genera or the orders belonging to these classes, those which feed upon Cryptogamia and Gymnospermia, were able to exist at a more ancient period. Amongst the multitude of animals which live at the expense of the angiospermous Dicotyledons, there is, moreover, a great quantity which are dependent upon one another; thus the carnivorous Vertebrata, the coprophagous or parasitic Insects, &c., could only make their appearance after certain other animals.

15. Progressive development does not consist only in the fact that new and more perfect types became added to the inferior types which existed before, but also in the circumstance that these latter decreased in importance from their point of culmination, and finally became entirely extinct. As a matter of course, certain types appeared from the first with their maximum. We consequently find simultaneously in each subkingdom, and even in each class of organized beings, types in course of development and others in course of diminution. The types which have a tendency to disappear are inferior types in regard to their organization or to the terripetal series (for example the Cephalopoda). The types which go on multiplying, on the contrary, occupy a higher place in one or other of these points of view. The groups which tend thus to replace each other are generally met with in the mesolithic period; but sometimes also they are separated by a longer or shorter interval. Besides, there exist groups of organisms of which the numerical development remains nearly the same through all periods. These are, for the most part, inferior orders or suborders, composed, perhaps, sometimes of two groups tending to replace each other.

16. All the great phænomena relating to the order of appearance of the different subdivisions of the organized kingdom result from the laws which we have here developed, and which may be summed up as follows:—*a*, adaptation to external conditions; *b*, terripetal movement; *c*, progressive development, that is to say, the successive appearance of forms with more and more complicated organization. The apparition of all these subdivisions is subordinated to these laws, with the exception of certain groups of secondary importance (suborders or families). Among these few and unimportant exceptions we may cite the late appearance of certain groups of Teleostian fishes, the premature appearance of certain terrestrial Reptiles (Thecodont and Acrodont Lacertians) which preceded the aquatic Saurians (Nexipoda and Emydosauria), and the rapid extinction of the Dinosauria, with so high an organization, at the moment of the appearance of Mammalia*. But these facts are so isolated, that

* As Dinosaurian reptiles occur in the Trias and the Lias, and as small

they can only be regarded as exceptions to the rule. It is nevertheless true that if, in these considerations, we choose to descend to the families of least importance, we shall see these exceptions become multiplied. But although the laws which we have just enumerated have, without the least doubt, presided over the creation, we are far from pretending that they are as mathematically absolute (excepting, of course, the negative and decisive effects of the law of external conditions of existence) as the law of universal attraction, the law of affinity, or any other law which admits of no exception. Moreover we do not yet know what rule the Creator himself has adopted for the determination of the systematic order of creatures.

17. A great number of phænomena certainly appear to fulfil the law of the successive development of series of organisms answering to embryonal types, such as has been formulated by M. Agassiz. Nevertheless the different characters presented by organisms resulting from the metamorphosis of an embryonal type are not all signs of a gradual perfecting. They are variations upon a single theme of organization, upon a single fundamental idea.

18. All the phænomena which we deduce from the law of adaptation to the external circumstances of existence, from the law of terripetal evolution, and from that of progressive development, show us a regular progress from the commencement to the close of geological epochs. Nevertheless there are two moments which, from their importance, stand out by themselves upon this uniform course of the history of the earth—one terminating the palæolithic, and the other immediately preceding the cænolithic period. The former corresponds with the extinction of the marshes of *Stigmaria*: this extinction involved the cessation of peculiar and very general phænomena on the surface of the earth, which were intimately connected with the existence of these singular bogs; it also involved the disappearance of a great number of palæolithic types. The second corresponds with the disappearance of Ammonites and Belemnites,—the first appearance, at all events on a considerable scale, of angiocarpous Dicotyledons, of the Teleostian fishes, of Birds inhabiting trees, and lastly of Mammalia. By this means, the multiplication of the number of genera and species received a fresh impulse. From this moment date the first traces of a differentiation of climates corresponding with the different zones of the terrestrial globe.

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mammals are found so low down as in the Trias, the co-existence of these forms, until the extinction of the Dinosaurs in the Cretaceous era, would appear to have extended over a long period of time,—contrary to the opinion expressed by the author.—Ed. *Annals.*

II. *Results of investigations regarding the gradation or simultaneousness of the appearance and disappearance of organized beings.*

The results at which we have arrived, with regard to the gradual or simultaneous extinction of all the organisms of a single epoch, may be summed up in the following manner:—

1. The creation of new species and the disappearance of older types went on continuously, with the exception of slight oscillations, without being restricted to certain periods of creation, although it is easy to imagine that certain geological events may have, here and there, induced the simultaneous extinction of a larger or smaller number of species.

2. The duration of existence has been very variable, according to the species. Certain specific types have endured 2, 3, 4, or 5 times as long as others, so that some even existed only during a small fraction of the time necessary for the production of a formation in the geological sense of the word, whilst others survived the deposition of two or three formations, or even more. These phænomena might take place only at a certain point of the surface of the globe, and not present themselves elsewhere.

3. There are, consequently, no definite formations in the palæolithic sense of the word, no definite creations, no successive and well-marked floras or faunas, any more than there exists any formation which simultaneously maintains the same mineralogical characters, the same thickness, and the same lithological and palæontological characters in all parts of the world.

4. A geological formation, or a geological flora or fauna, is the totality of the sedimentary strata which have been formed upon the whole earth during a certain space of time, or the totality of the animals and plants which have lived during that space of time. It is of little consequence here, whether the lithological character, the thickness, and the limits of demarcation of these strata have been uniform over all the surface of the globe, or have varied in different places, assuming here one aspect, there another; it is of little consequence whether the various species of organisms belonging to this epoch may have lived from its commencement to its termination, only endured for a portion of this time, or passed the limits assigned to this formation.

5. When the deposition of identical strata, according with an identical and constant state of the sea, continued longer in one country than in another, the population of this sea and the organic remains of this population might exist there longer without undergoing modification.

6. When an identical state of the sea reappeared during the

deposition of an immediately consecutive formation, or after a longer or shorter interval during which other formations might be deposited, the same marine population might reappear in the same locality and give rise to identical organic *débris*, enclosed in superior strata. Thus are formed what are termed *colonies* in Geology. It is probable, however, that this phænomenon could only present itself when the same species had continued to live in the interval, perhaps exceedingly reduced in number, in some other locality. We have nevertheless shown how it may happen that remains of perfectly identical species may pass into rocks of a nature quite different, and deposited by very different seas.

7. There probably exist no formations immediately superposed upon each other, no consecutive faunas and floras, without certain organisms being common to both. The number of common species may vary between 0·01 and 0·10.

8. When, however, in certain localities there have been sudden movements of the soil, heating of the crust of the earth, emissions of sulphurous vapours, carbonic acid, or other injurious gases, long interruptions in the formation of deposits, upheavals of strata, &c., it most frequently happens that the passage of species from one stratum to another is more rare than when the deposits have been formed regularly and without any interruption.

9. The average absolute duration of organisms was sufficiently long to give us no reason for astonishment at the important differences presented by species in this respect, although the history of these species is often told us only by strata of but slight thickness, so that it often happens that we regard as simultaneous, phænomena which have been separated by long periods of time.

[To be continued.]

VIII.—*Observations on the Shell and Animal of* Hybocystis, *a new genus of* Cyclostomidæ, *based on* Megalomastoma gravidum *and* Otopoma Blennus, *B.*; *with Notes on other living Shells from India and Burmah.* By W. H. Benson, Esq.

Dr. Pfeiffer has divided the genus *Megalomastoma* into three sections:—1st, *Hainesia*, which he considers to be possibly distinct generically; 2nd, *Farcimen*, Troschel; and, 3rd, *Megalomastoma* proper. In the first section, characterized by its oval aperture, angular above, he places the Siamese *M. Myersi*, Haines, *M. croceum*, Sow., and *M. bifasciatum*, Sow. The operculum is unknown. In *Farcimen* he has included my Burmese *M. gravidum*, together with other species provided with the normal thin cor-